R & D facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

04/2004

CONTACT POINTS

David Tucker, Ph.D.
(Experimental Facility)
Physical Scientist
304-285-1331
dtucker@netl.doe.gov

Eric Liese
(Systems Modeling)
Mechanical Engineer
304-285-4610
eliese@netl.doe.gov

Larry Lawson
(Controls and Simulation)
Electronics Engineer
304-285-4735
llawso@netl.doe.gov

Randall Gemmen, Ph.D.
Team Leader for Fuel Cells Research
304-285-4536
rgemme@netl.doe.gov

Diane (DeeDee) Newlon
Technology Transfer Manager
304-285-4086
r diane.newlon@netl.doe.gov

Hybrid Performance Project

The combination of turbines and fuel cells is expected to meet the efficiency targets of advanced Vision21 power plants. While the efficiency benefits of hybrid plants are well recongized, controlling the flow of power from both the fuel cell and turbine during load changes is expected to be more complicated than in conventional power systems. In some hybrid configurations, the fuel cell flows cannot be abruptly disrupted, yet the turbine engine power needs to be quickly adjusted to meet changes in load without over or underspeed problems. A variety of strategies are possible to address this issue, such as adding load, energy storage devices, or defining new control strategies. Researchers at NETL are investigating the control strategies with both computer simulations, and with the experimental Hybrid Performance Project (Hyper) Facility.

Capabilities

The Hybrid Performance Project (Hyper) was initiated by the Office of Science and Technology at the National Energy Technology Laboratory (NETL), U.S. Department of Energy to examine fundamental issues related to the dynamic operability of fuel cell gas turbine hybrid systems. Developing an understanding of dynamic issues related to the coupling of fuel cell and gas turbine technologies is critical to responsive control of the hybrid system during transient events. The preliminary phases of the project have included detailed dynamic modeling of solid oxide fuel cell (SOFC) gas turbine hybrid and molten carbonate fuel cell (MCFC) gas turbine hybrid systems. Modeling results led to the development of an experimental fuel cell gas turbine system simulation facility to examine the effects of transient events on the dynamics of these systems. The test facility is used to evaluate control strategies for improving system response to transient events and load following, and to validate results of dynamic system models. The facility makes use of pressure vessels and a model controlled burner to simulate the transient behavior of the solid oxide fuel cell. The air distribution manifold volume, cathode volume and flow impedance of the fuel cell, as well as the post combustion volume are represented by pressure vessels in the system so that residence times can be physically simulated. A reduced order fuel cell model operating in real time is used to control a burner to simulate the thermal characteristic of the effluent exiting the post combustor of the fuel cell system. The turbomachinery used in the facility is a single shaft Garrett auxiliary power unit with a direct coupled turbine, compressor and 120kW generator connected to a resistive load bank.

Because the fuel cell in the system is simulated by a burner and pressure vessels, the impact of system transients can be evaluated without risk of damage to the more fragile fuel cell components. A variety of fuel cell configurations can be studied by altering the real-time model used to control the burner. The facility is capable of simulations for systems up to 1MW. The project will provide quantification of design basis trade-offs between system efficiency and dynamic robustness. Control

ADDRESS

National Energy Technology Laboratory

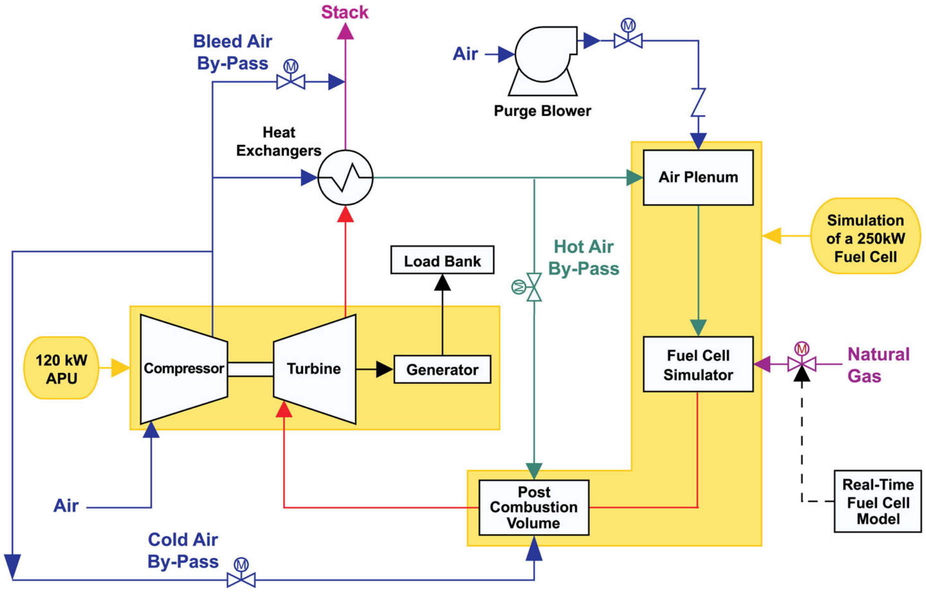
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4403 fax

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4604 fax

WEBSITE

www.netl.doe.gov/products/r&d

platform capabilities can be demonstrated, and power systems synchronization and unit load management can be evaluated using the facility. The initial phases of this hybrids research effort focus on the simulation of a direct fired SOFC gas turbine hybrid system, with the turbine in a bottoming configuration to recover waste heat from the fuel cell. The configuration is illustrated in the figure below.



Opportunities

The Hyper experimental facility and modeling results are available for public research collaboration with universities, industry and other research institutions. In addition to planned NETL studies, the Hyper facility is intended to provide a test platform for novel sense and control strategies that may emerge from university or small business research projects. Collaboration with academic, non-profit, or commercial research groups can be arragned under a variety of cooperative programs, such as a Cooperative Research and Development Agreement (CRADA), and student or visiting scholar programs.